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REPORT OF COOPERATIVE RESEARCH ON INSECT CONTROL IN FARM STORED
GRAIN

No. 20. Period--April 1 to June 30, 1946

Compiled by R. T. Cotton, Entomologist
Cereal and Forage Insect Investigations
Bureau of Entomology and Plant Quarantine
U. S. Department of Agriculture
Manhattan, Kansas

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of unpublished data ~~and should be kept confidential~~.
It is made available in its present form for the
convenience of the various State and Federal
Agencies concerned with the preservation of stored
grain from insect damage.

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TERMINATION OF REPORTS

Owing to the great need for wheat in the famine areas of Europe, the entire stock of wheat at the Experimental Storage Site in Hutchinson, Kansas has been released for export. Experimental observations have necessarily been terminated and the quarterly mimeographed reports are being discontinued with this issue.

WHEAT STORAGE

Effect of Temperature, Moisture and Dockage on the Survival and Reproduction of the red flour beetles of the genus Tribolium*

In the 19th report, pp. 12-16, partial results were reported relative to breeding experiments conducted at a constant temperature of 95° F. These experiments were completed during the quarter and survival records are summarized for the red flour beetle in table 1 and for the confused flour beetle in table 3. A constant temperature of 95° F. is not favorable for survival of the adults of either species. The moisture content of the wheat appears to be of greater significance than the amount of dockage present. A 15% moisture content appears to be much more favorable than either 9% or 12%.

Data regarding the reproduction of the red flour beetle and the confused flour beetle are given in tables 2 and 4.

The results are somewhat erratic; however, there is a significant trend towards increased reproduction as the moisture content and dockage content increases.

Table 1.--Percent survival of T. castaneum in 9, 12, and 15% moisture wheat with varying amounts of dockage at 95° F.

Moisture content of wheat and food media	Percent survival after								
	12	13	14	15	16	17	18	19	
	weeks	weeks	weeks	weeks	weeks	weeks	weeks	weeks	weeks
<u>9% Wheat</u>									
Clean wheat	:	:	:	:	:	:	:	:	:
Same + 0.5% Dock.	:	:	:	:	:	:	:	:	:
Same + 1.0% "	:	:	:	:	:	:	:	:	:
Same + 2.0% "	:	:	:	:	:	:	:	:	:
Same + 4.0% "	:	:	:	:	:	:	:	:	:
Same + 8.0% "	:	:	:	:	:	:	:	:	:
	50	50	50	45	45	45	40	40	
<u>12% Wheat</u>									
Clean wheat	:	:	:	:	:	:	:	:	:
Same + 0.5% Dock.	:	:	:	:	:	:	:	:	:
Same + 1.0% "	:	:	:	:	:	:	:	:	:
Same + 2.0% "	:	:	:	:	:	:	:	:	:
Same + 4.0% "	:	:	:	:	:	:	:	:	:
Same + 8.0% "	:	:	:	:	:	:	:	:	:
	5	5	0						
	0								
	0								
	0								
	20	15	15	15	15	15	15	15	15
	10	10	10	10	10	10	10	10	10
<u>15% Wheat</u>									
Clean wheat	:	:	:	:	:	:	:	:	:
Same + 0.5% Dock.	:	:	:	:	:	:	:	:	:
Same + 1.0% "	:	:	:	:	:	:	:	:	:
Same + 2.0% "	:	:	:	:	:	:	:	:	:
Same + 4.0% "	:	:	:	:	:	:	:	:	:
Same + 8.0% "	:	:	:	:	:	:	:	:	:
	15	15	15	15	10	10	10	10	10
	0								
	0								
	25	20	20	20	20	20	20	20	15
	20	20	20	20	20	20	20	20	20

* - Reported by R. T. Cotton and J. C. Frankenfeld.

wheat with varying amounts of dockage at 95° F.

[illegible]

Table 3.--Percent survival of *T. confusum* in 9, 12, and 15% moisture wheat with varying amounts of dockage at 95° F.

Moisture content :		Percent survival after							
of wheat and		12	13	14	15	16	17	18	19
food media		weeks:	weeks:	weeks:	weeks:	weeks:	weeks:	weeks:	weeks:
<u>9% Wheat</u>		:	:	:	:	:	:	:	:
Clean wheat		:	:	:	:	:	:	:	:
Same + 0.5% Dock.		:	:	:	:	:	:	:	:
Same + 1.0%	"	:	:	:	:	:	:	:	:
Same + 2.0%	"	:	:	:	:	:	:	:	:
Same + 4.0%	"	:	15	15	15	15	15	10	10
Same + 8.0%	"	:	35	30	20	20	20	20	20
<u>12% Wheat</u>		:	:	:	:	:	:	:	:
Clean wheat		:	:	:	:	:	:	:	:
Same + 0.5% Dock.		:	20	15	15	15	10	10	10
Same + 1.0%	"	:	5	5	5	5	5	0	:
Same + 2.0%	"	:	0	:	:	:	:	:	:
Same + 4.0%	"	:	0	:	:	:	:	:	:
Same + 8.0%	"	:	0	:	:	:	:	:	:
<u>15% Wheat</u>		:	:	:	:	:	:	:	:
Clean wheat		:	30	30	30	30	30	25	15
Same + 0.5% Dock.		:	0	:	:	:	:	:	:
Same + 1.0%	"	:	15	15	15	10	10	10	10
Same + 2.0%	"	:	45	35	35	35	25	25	20
Same + 4.0%	"	:	40	35	15	15	15	15	10
Same + 8.0%	"	:	0	:	:	:	:	:	:

Table 4.--Weekly recovery of *T. confusum* from 9, 12, and 15% moisture wheat with varying amounts of dockage at 95° F.

[illegible]

Egg laying records of the red flour beetle and the confused flour beetle over a 24-week period were also given in report No. 19. Additional records are given in table 5 covering a 37-week period. In cultures where the food was changed every week or month the adults of the red flour beetle have almost ceased laying, whereas in the cultures in which the food was unchanged egg laying continues at a good rate. More eggs have been laid by the females in the other two cultures to date. The confused flour beetles in all cultures are still laying eggs and have already laid more than twice as many eggs per female as the red flour beetles. The beetles in the cultures in which the food was changed at weekly or monthly intervals have laid a few more eggs than those in the culture in which the food was unchanged.

Table 5.--Egg laying record of 10 female *T. castaneum* and 10 female *T. confusum* over a period of 37 weeks at 75° F. and 46% R.H.

Egg laying period	Number eggs laid by 10 females of							
	<i>T. castaneum</i>				<i>T. confusum</i>			
	Food		Food		Food		Food	
	changed weekly	Food changed every 4 weeks	unchanged	Food changed weekly	changed every 4 weeks	Food unchanged	changed weekly	Food unchanged every 4 weeks
1-24 weeks	2746	2799	1971	5100	5541	3061		
25th week	3	23	66	102	85	189		
26th "	0	17	59	87	89	169		
27th "	9	29	53	72	112	174		
28th "	0	14	33	25	70	174		
29th "	0	44	34	111	116	191		
30th "	0	27	46	88	119	145		
31st "	0	0	27	72	68	133		
32nd "	0	0	50	39	96	121		
33rd "	0	0	37	41	104	128		
34th "	0	0	35	49	86	143		
35th "	4	0	44	77	116	145		
36th "	8	0	54	90	139	145		
37th "	7	0	48	21	78	138		
Totals	2777	2953	2557	5974	6818	5054		
Ave. per female	277.7	295.3	255.7	597.4	681.8	505.4		

Egg-laying records of ten female red flour beetles in 12% and 15% moisture flour at 70° F. are given in table 6 for a period of 16 weeks. Oviposition is at a slightly higher rate in the 15% moisture flour, but in both cultures at this temperature the oviposition rate is much lower than at a temperature of 75° F.

Table 6.--Egg-laying record of ten female *Tribolium castaneum* over a period of 16 weeks at 70° F. in 12% and 15% moisture flour.

Egg-laying period:	Number of eggs laid by 10 females in	
	12% moisture flour	15% moisture flour
1st week	0	0
2nd "	79	82
3rd "	83	84
4th "	35	65
5th "	42	45
6th "	8	17
7th "	10	24
8th "	25	56
9th "	35	54
10th "	36	53
11th "	16	22
12th "	13	23
13th "	14	9
14th "	20	16
15th "	6	12
16th "	7	7
Totals	429	569
Ave. per female	42.9	56.9

Relative Value of Activated and Non-activated Magnesium Oxides as Seed Protectants*

The suggestion was made by a manufacturer of magnesium oxides that the effectiveness of magnesium oxide in affording protection to stored seed may be due primarily to its activity. By "activity" is meant the power to absorb moisture, colors, odors, etc. It was thought by the manufacturer that the activated magnesium oxides would cause the death of insects by dehydration. This conception of the way inert dusts cause the death of insects is at variance with the current belief. Actually some stored grain insects will breed normally in a desiccator, the dehydrating effect of the desiccating chemical having no effect on the insect. The chemical absorbs moisture from the air and this in turn may be absorbed by the wheat so that actually more moisture may be available for insects in wheat treated with an active magnesium oxide.

To test the relative insecticidal value of "activated" and "non-activated" magnesium oxides, samples of light, medium, and heavy magnesium oxides were obtained. Two samples of the light oxide were obtained that were identical except that one was activated, similarly one activated and one non-activated heavy oxide were secured and an activated medium oxide consisting of a mixture of the light and heavy oxides. The mixture of the two being made before calcination.

Five hundred gram samples of both 12 and 14% moisture wheat were treated with various dosages of the 5 different oxides and replicated 3 times. Fifteen adult rice weevils and confused flour beetles were introduced into each sample. Examinations were made at weekly intervals with the results shown in tables 7 and 8.

From the data of tables 7 and 8 it is evident that "activation" of the magnesium oxide does not increase the insecticidal value. However, voluminosity is correlated with insecticidal action since the light magnesium oxides are effective at lower dosages than the heavy oxides.

Table 7.--Relative insecticidal value of activated and non-activated magnesium oxides in protecting 12% moisture seed wheat against the rice weevil and the flour beetle, 15 adult weevils and flour beetles added to each sample.

No. of sample:	Type of magnesium oxide	Dosage : Per 500 gms. of wheat		Percent rice weevils dead after		Percent flour beetles dead after	
		1 week: 2 weeks:		1 week: 2 weeks:		1 week: 2 weeks:	
1	MgO light U.S.P. 5485	1 gram:	93.3	100	100	100	100
2	Do.	1 "	93.3	100	100	100	100
3	Do.	0.5	100	100	100	100	100
4	Do.	0.5	100	100	100	100	100
5	Do.	0.25	86.6	100	100	100	100
6	Do.	0.25	80.0	100	100	100	100
7	Do.	0.125	53.3	80	60	80	80
8	Do.	0.125	26.6	53.3	0	20	20
9	MgO light activated 5478	1 gram:	100	100	100	100	100
10	Do.	1 "	100	100	100	100	100
11	Do.	0.5	100	100	100	100	100
12	Do.	0.5	100	100	93.3	100	100
13	Do.	0.25	100	100	100	100	100
14	Do.	0.25	93.3	93.3	86.6	86.6	86.6
15	Do.	0.125	46.6	86.6	66.6	73.3	73.3
16	Do.	0.125	60.0	80.0	66.6	73.3	73.3
17	MgO medium activated 5486	1 gram:	100	100	100	100	100
18	Do.	1 "	100	100	100	100	100
19	Do.	0.5	100	100	100	100	100
20	Do.	0.5	100	100	100	100	100
21	Do.	0.25	100	100	86.6	93.3	93.3
22	Do.	0.25	93.3	100	93.3	100	100
23	Do.	0.125	60.0	60.0	93.3	93.3	93.3
24	Do.	0.125	40.0	53.3	53.3	60.0	60.0
25	MgO heavy U.S.P. 5483	1 gram:	86.6	100	86.6	100	100
26	Do.	1 "	73.3	100	100	100	100
27	Do.	0.5	93.3	100	86.6	86.6	86.6
28	Do.	0.5	80.0	100	80.0	80.0	80.0
29	Do.	0.25	26.6	73.3	53.3	73.3	73.3
30	Do.	0.25	40.0	86.6	26.6	53.3	53.3
31	Do.	0.125	6.6	33.3	26.6	26.6	26.6
32	Do.	0.125	6.6	20.0	13.3	26.6	26.6
33	MgO heavy activated 5484	1 gram:	100	100	100	100	100
34	Do.	1 "	100	100	93.3	100	100
35	Do.	0.5	13.3	60.0	40.0	46.6	46.6
36	Do.	0.5	60.0	86.6	80.0	93.3	93.3
37	Do.	0.25	60.0	80.0	60.0	86.6	86.6
38	Do.	0.25	13.3	46.6	0	13.3	13.3
39	Do.	0.125	26.6	86.6	6.6	40.0	40.0
40	Do.	0.125	6.6	20.0	6.6	13.3	13.3

Table 8.--Relative insecticidal value of activated and non-activated magnesium oxides in protecting 14% moisture seed wheat against the rice weevil and confused flour beetle. 15 adult weevils and flour beetles added to each 500 gram sample of wheat.

No. of: sample:	Type of magnesium oxide	Dosage per 500: gms. of: wheat	Percent Rice		Percent flour	
			weevils dead		beetles dead	
			after	after	after	after
			1 week:	2 weeks:	1 week:	2 weeks:
1	MgO light U.S.P. 5485	1 gram:	73.3	100	100	100
2	Do.	1 "	86.6	100	100	100
3	Do.	0.5	66.6	100	80.0	80.0
4	Do.	0.5	73.3	93.3	86.6	93.3
5	Do.	0.25	26.6	73.3	86.6	93.3
6	Do.	0.25	0	0	33.3	46.6
7	Do.	0.125	6.6	6.6	20.0	20.0
8	Do.	0.125	6.6	26.6	13.3	13.3
9	MgO light activated 5478	1 gram:	80.0	100	100	100
10	Do.	1 "	80.0	86.6	100	100
11	Do.	0.5	53.3	66.6	86.6	93.3
12	Do.	0.5	53.3	53.3	93.3	100
13	Do.	0.25	40.0	53.3	26.6	53.3
14	Do.	0.25	40.0	40.0	73.3	73.3
15	Do.	0.125	13.3	20.0	20.0	26.6
16	Do.	0.125	20.0	40.0	26.6	40.0
17	MgO medium activated 5486	1 gram:	86.6	100	100	100
18	Do.	1 "	80.0	100	100	100
19	Do.	0.5	80.0	86.6	86.6	100
20	Do.	0.5	60.0	93.3	80.0	80.0
21	Do.	0.25	80.0	93.3	73.3	86.6
22	Do.	0.25	33.3	40.0	73.3	80.0
23	Do.	0.125	6.6	13.3	20.0	26.6
24	Do.	0.125	46.6	46.6	40.0	46.6
25	MgO heavy U.S.P. 5483	1 gram:	20.0	80.0	73.3	86.6
26	Do.	1 "	20.0	80.0	86.6	86.6
27	Do.	0.5	13.3	33.3	40.0	53.3
28	Do.	0.5	0	13.3	53.3	60.0
29	Do.	0.25	0	13.3	6.6	13.3
30	Do.	0.25	0	6.6	20.0	40.0
31	Do.	0.125	0	0	0	0
32	Do.	0.125	0	0	13.3	20.0
33	MgO heavy activated 5484	1 gram:	0	20.0	60.0	60.0
34	Do.	1 "	6.6	13.3	53.3	60.0
35	Do.	0.5	0	20.0	46.6	53.3
36	Do.	0.5	6.6	20.0	33.3	40.0
37	Do.	0.25	6.6	20.0	13.3	20.0
38	Do.	0.25	0	0	6.6	6.6
39	Do.	0.125	0	0	6.6	6.6
40	Do.	0.125	13.3	86.6	73.3	86.6

Insecticidal Value of Benzene Hexachloride against Stored Grain Insects*

R. T. Cotton and J. C. Frankenfeld

The insecticidal value of benzene hexachloride against stored grain insects was tested by exposing adults of the confused flour beetle and larvae of the Indian meal moth with samples of wheat treated with mixtures of pyrophyllite and benzene hexachloride. The mixtures were made from the pure gamma isomer of benzene hexachloride as well as from crude (plain and steamed) benzene hexachloride containing between 10% and 11% of the gamma isomer.

Observations were made at weekly intervals on the condition of the insects in the various samples. A dosage equivalent to 2 parts per million of the gamma isomer of benzene hexachloride gave a complete kill.

The objectionable odor of benzene hexachloride is imparted to treated grain so that it is doubtful whether it could ever be used for protecting grain intended for food or feed.

Table 9.--Insecticidal effect of benzene hexachloride against the confused flour beetle in wheat.

Sample: No.	Dust used	:Dosage: :per 500: Percent kill after						
		:grams :wheat	: 1 :week	: 2 :weeks	: 3 :weeks	: 4 :weeks	: 5 :weeks	: 6 :weeks
		:grams	:	:	:	:	:	:
1	:1% crude in pyrophyllite**	: 0.1	: 0	: 0	: 0	: 0	: 3.3	: 3.3
2	: Do.	: 0.25	: 0	: 0	: 0	: 0	: 0	: 0
3	: Do.	: 0.5	: 10	: 20	: 33.3	: 40	: 50.0	: 50.0
4	: Do.	: 1.0	: 6.6	: 36.6	: 83.3	: 93.3	: 96.6	: 100
5	: Do.	: 2.0	: 43.3	: 93.3	: 96.6	: 100	:	:
6	: Do.	: 3.0	: 23.3	: 90.0	: 100	:	:	:
7	: Do.	: 4.0	: 36.6	: 83.3	: 100	:	:	:
8	: Do.	: 5.0	: 26.6	: 100	:	:	:	:
9	:1% Steamed crude in pyrophyllite**	: 0.1	: 0	: 13.3	: 13.3	: 13.3	: 13.3	: 13.3
10	: Do.	: 0.25	: 20.0	: 20.0	: 20.0	: 26.6	: 26.6	: 26.6
11	: Do.	: 0.5	: 43.3	: 50.0	: 53.3	: 53.3	: 56.6	: 56.6
12	: Do.	: 1.0	: 66.6	: 86.6	: 90.0	: 90.0	: 96.6	: 100
13	: Do.	: 2.0	: 30.0	: 50.0	: 93.3	: 100	:	:
14	: Do.	: 3.0	: 90.0	: 100	:	:	:	:
15	: Do.	: 4.0	: 83.3	: 100	:	:	:	:
16	: Do.	: 5.0	: 70.0	: 100	:	:	:	:
17	:2% pure gamma in pyrophyllite	: 0.025	: 10.0	: 16.6	: 50.0	: 66.6	: 80.0	: 96.6
18	: Do.	: 0.05	: 23.3	: 33.3	: 60.0	: 96.6	: 100	:
19	: Do.	: 0.1	: 56.6	: 70.0	: 93.3	: 100	:	:
20	: Do.	: 0.25	: 66.6	: 93.3	: 100	:	:	:
21	: Do.	: 0.5	: 90.0	: 100	:	:	:	:
22	: Do.	: 1.0	: 100	:	:	:	:	:
23	: Check	:	: 0	: 0	: 0	: 0	: 0	: 0
		:	:	:	:	:	:	:

** - The crude material is reported to contain between 10 and 11% of the gamma isomer.

Table 10.--Insecticidal effect of benzene hexachloride against the Indian meal moth. 10 larvae placed in each sample.

Sample No.	Dust used	Dosage :		Percent kill after			
		per 500 :	grams :	1 :	2 :	3 :	4 :
		wheat :	grams :	week :	weeks :	weeks :	weeks :
1	1% crude in pyrophyllite*		1.0	0	10	100	
2	Do.		1.0	0	60	80	100
3	Do.		2.0	0	70	100	
4	Do.		2.0	20	50	100	
5	Do.		3.0	20	100		
6	Do.		3.0	20	100		
7	Do.		4.0	20	100		
8	Do.		4.0	30	100		
9	Do.		5.0	40	90	90	100
10	Do.		5.0	60	90	100	
11	1% steamed crude in pyrophyllite		1.0	0	30	100	
12	Do.		1.0	10	90	100	
13	Do.		2.0	0	90	100	
14	Do.		2.0	20	100		
15	Do.		3.0	10	100		
16	Do.		3.0	10	90	90	100
17	Do.		4.0	40	100		
18	Do.		4.0	30	100		
19	Do.		5.0	40	80	100	
20	Do.		5.0	30	90	100	
21	2% pure gamma in pyrophyllite		0.05	0	10	100	
22	Do.		0.05	0	30	80	100
23	Do.		0.1	20	90	100	
24	Do.		0.1	30	60	100	
25	Do.		0.25	30	100		
26	Do.		0.25	40	100		
27	Do.		0.5	20	100		
28	Do.		0.5	100			
29	Do.		1.0	40	100		
30	Do.		1.0	80	100		

* The crude material is reported to contain between 10 and 11% of the gamma isomer.

